Remarks

Please consider the following amendments and remarks in response to the Office Action mailed May 18, 2005.

Claim 1 has been amended to make it clear that the apparatus of the invention is for measuring the shape or surface characteristics of a work roll as explained in the first sentence of paragraph [0014] of the specification. The sensor employed in the apparatus is a non-contact measuring probe which is moved along a rail at a non-contact measuring distance from the surface of the roll as explained in paragraphs [0006], [0019] and [0022] of the specification. Many types of sensors can be used as explained in paragraph [0016] and therefore the term "analog" has been deleted from claim 1 and added in new dependent claim 15.

Method claim 8 has been amended in a manner consistent with the amendments made to claim 1 and new dependent claim 16 has been added.

Claim 12 has been amended for clarification in response to a rejection under 35 U.S.C. §112. The term "traces" in claims 11 and 12 has been replaced by "data points" based on paragraph [0017].

New claims 13 and 14 have been added to claim a method wherein the roll is rotated during measuring and the apparatus comprises a means for rotating the roll as explained in paragraph [0026] of the specification.

Rejections under 35 U.S.C. §112, Second Paragraph

Claims 5 and 7-12 have been rejected under 35 U.S.C. §112, second paragraph, as being indefinite.

As to claims 5 and 10, we have obtained literature to support the definitions of crown and traverse and the literature is appended at Exhibit A and Exhibit B. The crown is the highest point of a curvature between the starting point and ending point of a parabolic cylinder as described in an operating manual published by Pro-Mic Corporation on August 28, 1996, Exhibit A hereto. Traverse is a residual repeated pattern induced into the parabolic cylinder surface of a roll during the grinding process (i.e., grinding feed lines) as defined in Machinery's Handbook, Twenty-Third Edition, Fourth Printing, 1990, pp. 1080-1082, Exhibit B hereto.

As to claims 6 and 7, the baseline specification has to do with the accuracy of the probe. In the case of claim 6, the probe can measure to an accuracy of 0.0005 of an inch with a tolerance of ±1% and, in claim 7, the probe can measure with an accuracy of 0.00005 of an inch with a tolerance of ±0.5%.

Claim 8 has been amended as suggested by the Examiner to make it clear that the claim refers to one roll.

Claim 10 has been amended as suggested by the Examiner to make it clear that one measurement is displayed.

Claim 12 has been clarified as suggested by the Examiner to say that "or more" refers to more than 16,000 data points per second.

In view of the remarks and amendments referenced above, withdrawal of the rejections under 35 U.S.C. §112, second paragraph, is respectfully requested.

Rejections under 35 U.S.C. §112, First Paragraph

Claims 5, 6 and 7 have been rejected under 35 U.S.C. §112, first paragraph, as failing to comply with the enablement requirement. Applicants respectfully submit that

the foregoing amendments and remarks in response to the 35 U.S.C. §112, second paragraph, rejections suffice to overcome the 35 U.S.C. §112, first paragraph, rejections and withdrawal of the rejections is accordingly requested.

Rejections under 35 U.S.C. §103(a)

Claims 1-4 and 6-12 have been rejected under 35 U.S.C. §103(a) as being unpatentable over Hirayama, in view of White, et al. or Tait.

The present invention has to do with a non-contact apparatus and method for measuring the surface characteristics of work rolls that are used in the manufacture of sheet steel and other sheet metal products. Before the present invention was made, mechanical contact measuring devices were used to take measurements of surface properties, but such devices did not provide acceptable accuracy, repeatability or resolution. Applicant's claimed invention requires a non-contact sensor and a means for moving the sensor along a rail at a non-contact measuring distance from the surface of a work roll and in a line which is in parallel with the center line of the work roll. A means of collecting shape or surface characteristics data from the sensor is also required. None of the cited art considered alone or in the various combinations set forth in the Office Action would render obvious applicant's claimed invention.

Hirayama has to do with a device for measuring the gloss of electroconductive rollers used in image forming apparatus such as copiers and laser printers. This art is totally unrelated to the work roll art which is the subject of applicant's invention. Hirayama discloses the possibility of moving a gloss meter along the axial direction or the central axis of the electroconductive roller. But the reference does not disclose how the gloss meter would be moved in such direction and it does not collect data. White, et

al. and Tait cannot overcome the deficiencies of Hirayama because both White and Tait require the use of a sensor which is placed against the surface of a roll. At column 4 of White beginning with line 34, the reference describes a U-shaped aperture 28 which is placed against the surface 30 of casting 20. At column 4 beginning at line 4 of Tait a spring 34 is described which presses a pad against the roll periphery. Accordingly, both White and Tait describe contact type sensors which are moved along the surface of a roll in contrast to the non-contact device of applicant's claims. In the absence of hindsight, there is no reason why one skilled in the art would incorporate the non-contact sensor of Hirayama into the devices of White or Tait which require contact between the roll surface and the sensor. Withdrawal of the rejection based upon Hirayama in view of White or Tait is accordingly requested.

Tait's recording 42 teaching for data obtained by scanning, providing for a record to be subsequently studied, or White's mass data storage unit 62 that provides for a record to be subsequently studied cannot overcome the deficiencies of the combination of references applied because no combination of the references teach or suggest a means for moving a non-contact sensor along a linear rail at a non-contact measuring distance from the surface of a work roll and in a line which is in parallel with the center line of the work roll.

Claim 5 is rejected under 35 U.S.C. §103(a) as being unpatentable over Hirayama, in view of White, et al. or Tait, as applied against claim 1 and further in view of Gilmore. Gilmore is said to teach the use of multiple sensors to provide for measurements of an entire body in a shorter period of time. But Gilmore describes an ultrasonic inspection system in which a plurality of transducers is employed to take

readings at varying depths through the thickness of a billet. Accordingly, the sensors are all measuring the same kind of information, but at different depths. This is different from claim 5 which has to do with simultaneously measuring different kinds of surface characteristics. Furthermore, claim 5 depends from allowable base claim 1 and, as such, should be allowable as a dependent claim.

Claims 1-4, 6-9, 11 and 12 are rejected under 35 U.S.C. §103(a) as being unpatentable over Popovic, et al. in view of White, et al. or Tait.

Popovic teaches an aerodynamically floatable contactless device and there is no clear description of an assembly that moves the device. White and Tait are cited as teaching the use of rails to drive the sensor along the roller, but, as explained above, the White and Tait devices are designed to move contact type sensors and there is no suggestion that they could be used with a contactless system. Furthermore, the Popovic device maintains a constant distance from the measured surface. Applicant's claimed apparatus and method does not maintain the sensor at a constant distance from the surface of the roll, but instead maintains a non-contact measuring distance which is in parallel with the center line of the roll. It would not be possible for applicant's invention to measure certain surface characteristics such as crown and taper if a constant distance was maintained between the sensor and the surface of the work roll.

In view of the foregoing, withdrawal of the §103 rejection based on Popovic, et al. in view of White, et al. or Tait should be withdrawn.

Conclusion

The instant application is believed to be in condition for allowance. A Notice of Allowance of claims 1-16 is respectfully requested. The Examiner is invited to telephone the undersigned at (908) 722-0700 if it is believed that further discussions, and/or additional amendment would help to advance the prosecution of the instant application.

A petition for a one-month extension of time for this response is enclosed. If a further extension is needed, applicants request that this be considered a petition therefor. Please charge any required petition fee to the Deposit Account No. 14-1263.

Please charge any insufficiency of fees, or credit any excess, to the Deposit Account No. 14-1263.

Respectfully submitted,

William R. Robinson
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September 13, 2005

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16510-017

PRO-MIC *PLUS*

ELECTRONIC SADDLE MICROMETER

OPERATING INSTRUCTIONS

PLOTTER BASED SYSTEM II

PRO-MIC CORPORATION
Building C
2495 Boulevard of the Generals
Norristown, PA 19403-5236

610/630-9620

August 28, 1996

PRO-MIC CORPORATION

The Concept of True Crown vs. Maximum Reading

There does not seem to be general acceptance of the term "True Crown" in the roll grinding industry at this time. This may be due to the fact that in some special situations its contribution is felt to be negligible or thought to be too difficult for the average grinder operator to calculate. In either case, True Crown is now calculated automatically by PRO-MIC Corporation's PRO-MIC Electronic Saddle Micrometer, so a word of explanation is in order.

Please refer to Figure 1 for a description of the concept. For purposes of this discussion, assume that the roll is "skated" from left to right and has a contour as shown by the solid line. (With the PRO-MIC System, the roll may be skated in either direction, but left to right seems easier to visualize.)

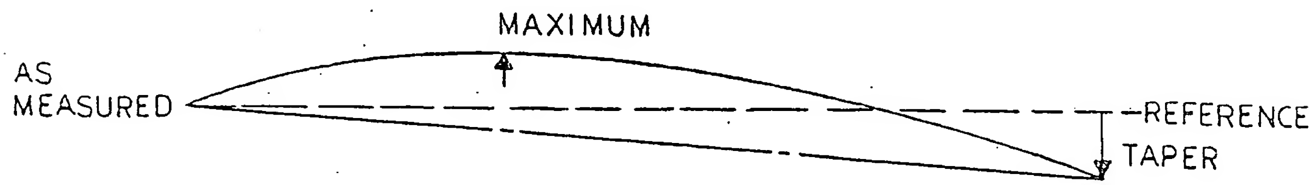

FIGURE 1

The PRO-MIC sets the starting point to "zero" or "reference" and measures plus or minus relative to an imaginary line (dashed line). Thus, for the roll contour, it will display Maximum and Taper as data points.

The Taper influences the Crown as follows. Assume this roll is the lower roll in a stand and the curve shown represents the top surface of the roll. To eliminate the effects of Taper, the right side bearing must be raised (or the left side bearing lowered). This is shown in Figure 2. This effectively eliminates the Taper but rotates the roll reference line and increases the effective crown (True Crown). Had the Taper been positive, eliminating the Taper would have reduced the effective crown.

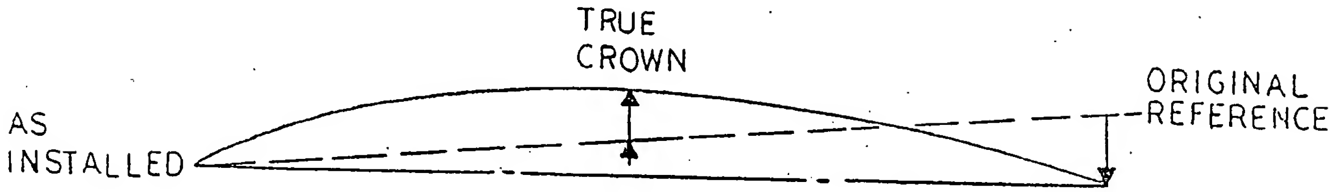

FIGURE 2

The location of the maximum determines how much the Taper influences the Crown. For example, if the maximum were all the way at the right, the Taper would add (or subtract) directly to the maximum. If the maximum is at the center, only a value of one-half of the Taper is added (or subtracted) to the maximum to generate the True Crown.

The drawings are deliberately drawn out of scale to illustrate the point. (Real rolls are 10's of inches long and real maximums are in thousandths of inches so the whole picture would appear flat.) However, the principle is valid as demonstrated. The grinder operator and supervisor don't have to worry about any of this in actual practice since the calculations are all performed automatically within the PRO-MIC. This should allow a better interchange of data between the roll shop and the mill and give:

"Another Good Roll"

For additional information call:

PRO-MIC CORPORATION
Building C
2495 Boulevard of the Generals
Norristown, PA 19403-5236
TEL: 610/630-9620 1-800-PRO-MIC-1
FAX: 610/630-3353

General B46 specifies the stylus shape and size, as well as, a traversing speed to allow an analog implementation of the filter. SHAPE, being a large area effect, is not greatly influenced by tip diameter, and it is impracticable to specify speed since the roll is usually traversed manually, however that is not necessary with modern digital filtering techniques. The way the area is computed also needs to be specified. B46 favors a numerical assessment based on an average (ignoring sign). The example of SHAPE analysis shown in the following section employs RMS which is more appropriate for noise-like and which also ignores the sign.

A preliminary version of the principles outlined in the proposed SHAPE standard has been implemented and has been applied to actual rolls to demonstrate the practicality of this analysis tool. Figure 9 shows how the Desired SHAPE Curve is fitted to the data without consideration of Crown and Taper which are not SHAPE problems per se.

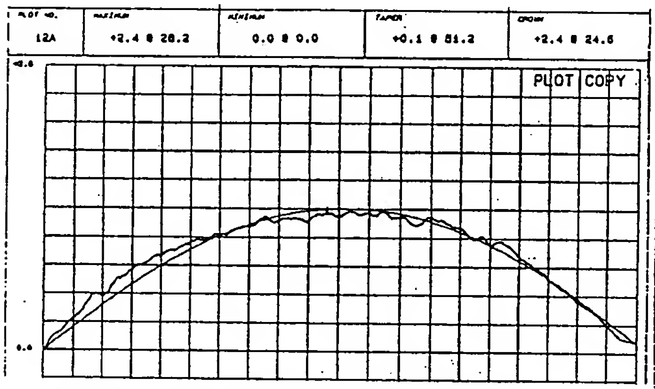

Fig. 9. "Best fit" Desired SHAPE curve fitted to measured data.

Figures 10 A, B, C, and D are replots of the corresponding figures of Figure 4, each of which had a crown in the center and appeared OK from a SHAPE standpoint. In Figure 10, a "best fit" perfect curve has been added and the difference between the actual data and the desired SHAPE curve plotted at the top (error). Also a SHAPE assessment numerical value representing the area of the error has been calculated. The error curve and the numerical factor seem to give a reasonable evaluation of the SHAPE error for each roll. Without this analysis technique none of this would have been apparent since the high crown hides the SHAPE and the crown was on center. Notice that 10D (4D) is actually the best SHAPEd even though the crown was shown to be off-center.

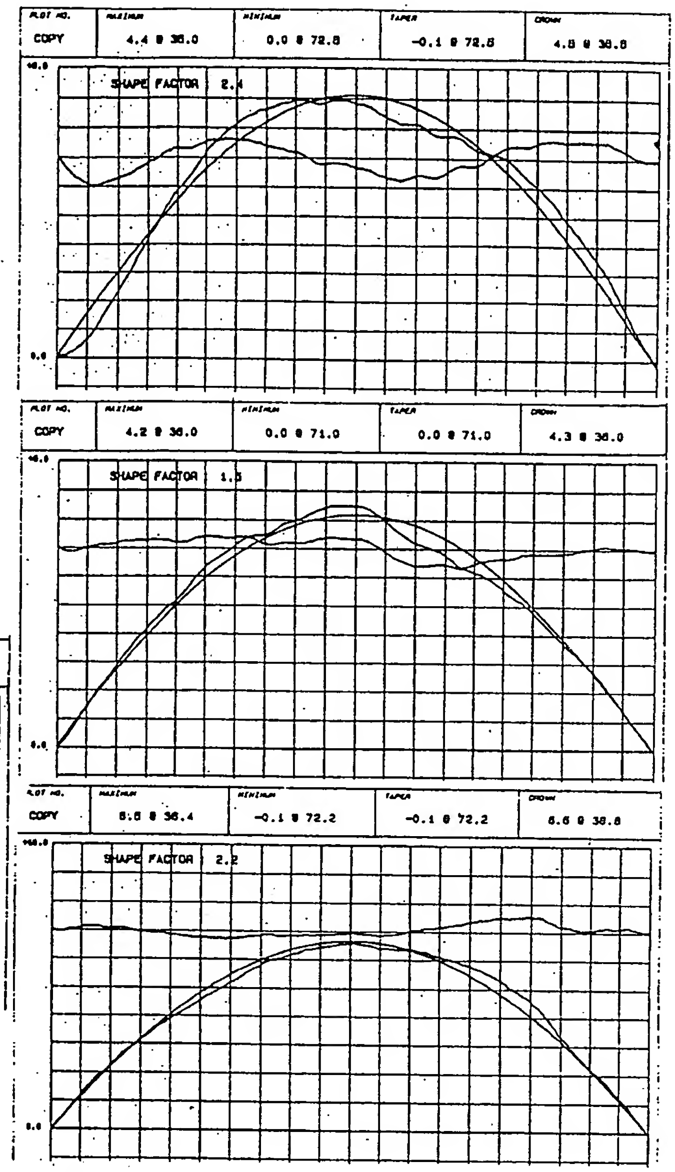

Fig. 10 A,B,C. Curves of Figure 4 replotted with desired shape curve fitted to data. Top curve is Error plotted to same scale. SHAPE FACTOR represents area difference.

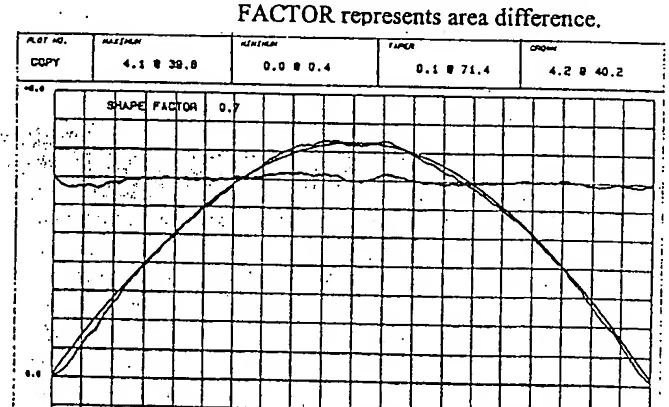

Fig. 10 D. Curve of Figure 4D replotted with desired shape curve fitted to data.

A Reference Book for the Mechanical Engineer, Designer, Manufacturing Engineer, Draftsman, Toolmaker, and Machinist

MACHINERY'S HANDBOOK

23rd Edition

By ERIK OBERG, FRANKLIN D. JONES
and HOLBROOK L. HORTON

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(5) *Improper dressing:* Use sharp diamond and hold rigidly close to wheel. It must not overhang too far. Check diamond in mounting.

(6) *Faulty work support or rotation:* Use sufficient number of work rests and adjust them more carefully. Use proper angles in centers of work. Clean dirt from footstock spindle and be sure spindle is tight. Make certain that work centers fit properly in spindles.

(7) *Improper operation:* Reduce rate of wheel feed.

(8) *Faulty traverse:* See "Uneven Traverse or In-feed of Wheel Head."

(9) *Work vibration:* Reduce work speed. Check workpiece for balance.

(10) *Outside vibration transmitted to machine:* Check and make sure that machine is level and sitting solidly on foundation. Isolate machine or foundation.

(11) *Interference:* Check all guards for clearance.

(12) *Wheel base:* Check spindle bearing clearance. Use belts of equal lengths or uniform cross-section on motor drive. Check drive motor for unbalance. Check balance and fit of pulleys. Check wheel feed mechanism to see that all parts are tight.

(13) *Headstock:* Put belts of same length and cross-section on motor drive. Incorrect work speeds. Check drive motor for unbalance. Make certain that headstock spindle is not loose. Check work center fit in spindle. Check wear of face plate and jackshaft bearings.

Spirals on Work (traverse lines with same lead on work as rate of traverse). — Sources of spirals include: (1) Machine parts out of line, and (2) truing. Suggested procedures for correction of these troubles are:

(1) *Machine parts out of line:* Check wheel base, headstock, and footstock for proper alignment.

(2) *Truing:* Point truing tool down 3 degrees at the workwheel contact line. Make edges of wheel face round.

(3) *Improper operation:* Don't let wheel traverse beyond end of work. Decrease wheel pressure so work won't spring. Use harder wheel or change feeds and speeds to make wheel act harder. Allow work to "spark-out." Decrease feed rate. Use proper number of work rests. Allow proper amount of tarry. Workpiece must be balanced if odd shape.

(4) *Coolant:* Use greater volume of coolant.

(5) *Wheel:* Rebalance wheel on mounting before and after truing.

(6) *Improper dressing:* Use same positions and machine conditions for dressing as in grinding.

(7) *Spindle bearings:* Check clearance.

(8) *Work:* Work must come to machine in reasonably accurate form.

Inaccurate Work Sizing (when wheel is fed to same position, it grinds one piece to correct size, another oversize, and still another undersize). — Sources of trouble are: (1) Improper work support or rotation, (2) wheel out of balance, (3) loaded wheel, (4) improper infeed, (5) improper traverse, (6) coolant, (7) misalignment, and (8) work. Suggested procedures for corrections of these troubles are:

(1) *Improper work support or rotation:* Keep work centers clean and lubricated. Regrind work center tips to proper angle. Be sure footstock spindle is tight. Use sufficient work rests properly spaced.

(2) *Wheel out of balance:* Balance wheel on mounting before and after truing.

(3) *Loaded wheel:* See "Wheel Defects."

(4) *Improper infeed:* Check forward stops of rapid feed and slow feed. When readjusting position of wheel base by means of the fine feed, move the wheel base back after making the adjustment and then bring it forward again to take up backlash and relieve strain in feed-up parts. Check wheel spindle bearings. Don't let excessive lubrication of wheel base slide cause "floating." Check and tighten wheel feed mechanism. Check parts for wear. Check pressure in hydraulic system. Set in-feed cushion properly. Check pistons to see that they are not sticking.

(5) *Improper traverse:* Check traverse hydraulic system and the operating pressure. Prevent excessive lubrication of carriage ways with resultant "floating" condition. Check to see if carriage traverse piston rods are binding. Carriage rack and driving gear must not bind. Change length of tarry period.

(6) *Coolant:* Use greater volume of clean coolant.

(7) *Misalignment:* Check level and alignment of machine.

(8) *Work:* Work pieces may vary too much in length permitting uneven center pressure.

Uneven Traverse or In-feed of Wheel Head. — Sources of uneven traverse or in-feed of wheel head are: (1) Carriage and wheel head, (2) hydraulic system, (3) interference, (4) unbalanced conditions, and (5) wheel out of balance. Suggested procedures for correction of these troubles are:

(1) *Carriage and wheel head:* Ways may be scored. Be sure to use recommended oil for both lubrication and hydraulic system. Make sure ways are not too smooth that they press out oil film. Check lubrication of ways. Check wheel feed mechanism, traverse gear and carriage rack clearance. Prevent binding of carriage traverse cylinder rods.

(2) *Hydraulic systems:* Remove air and check pressure of hydraulic oil. Check pistons and valves for oil leakage and for gumminess caused by incorrect oil. Check worn valves or pistons that permit leakage.

(3) *Interference:* Make sure guard strips do not interfere.

(4) *Unbalanced conditions:* Eliminate loose pulleys, unbalanced wheel drive motor, uneven belts, or high spindle keys.

(5) *Wheel out of balance:* Balance wheel on mounting before and after truing.

Fine Spiral or Thread on Work. — Sources of this trouble are: (1) Improper operation and (2) faulty wheel dressing. Suggested procedures for corrections of these troubles are:

(1) *Improper operation:* Reduce wheel pressure. Use more work rests. Reduce traverse with respect to work rotation. Use different traverse rates to break up pattern when making numerous passes. Keep edge of wheel from penetrating by dressing wheel face parallel to work.

(2) *Faulty wheel dressing:* Use slower or more even dressing traverse. Set dressing tool at least 3 degrees down and 30 degrees to the side from time to time. Tighten holder. Don't take too deep a cut. Round off wheel edges. Start dressing cut from wheel edge.

Narrow and Deep Regular Marks on Work. — Source of trouble is wheel too coarse. Use finer grain size.

Wide, Irregular Marks of Varying Depth on Work. — Source of trouble is wheel too soft. Use harder grade wheel. See "Wheel Defects."

Widely Spaced Spots on Work. — Source of trouble is oil spots or glazed areas on wheel face. Balance and true wheel. Keep oil from wheel face.

Irregular "Fish-tail" Marks of Various Lengths and Widths on Work. — Source of trouble is dirty coolant. Clean tank frequently. Use filter for fine finish grinding. Flush wheel guards after dressing or when changing to finer wheel.

Wavy Traverse Lines on Work. — Source of trouble is wheel edges. Round off. Check for loose thrust on spindle and correct if necessary.

Irregular Marks on Work. — Cause is loose dirt. Keep machine clean.

Deep, Irregular Marks on Work. — Source of trouble is loose wheel flanges. Tighten and make sure blotters are used.

Isolated Deep Marks on Work. — Source of trouble is: (1) Grains pull out, coolant too strong; (2) coarse grains or foreign matter in wheel face; and (3) improper dressing. Respective suggested procedures for corrections of these troubles are: (1) Decrease soda content in coolant mixture, (2) dress out, and (3) use sharper dressing tool. Brush wheel after dressing with stiff bristle brush.

Grain Marks on Work. — Source of trouble is: (1) Improper finishing cut; (2) grain sizes of roughing and finishing wheels differ too much; (3) dressing too coarse; and (4) wheel too coarse or too soft. Respective suggested procedures for corrections of these troubles are: (1) Start with high work and traverse speeds; finish with high work speed and slow traverse, letting wheel "spark-out" completely; (2) finish out better with roughing wheel or use finer roughing wheel; (3) use shallower and slower cut; and (4) use finer grain size or harder grade wheel.

Inaccuracies in Work. — Work out-of-round, out-of-parallel, or tapered. Source of trouble is: (1) Misalignment of machine parts, (2) work centers, (3) improper operation, (4) coolant, (5) wheel, (6) improper dressing, (7) spindle bearings, and (8) work. Suggested procedures for corrections of these troubles are:

(1) *Misalignment of machine parts:* Check headstock and tailstock for alignment and proper clamping.

(2) *Work centers:* Centers in work must be deep enough to clear center point. Keep work centers clean and lubricated. Check play of footstock spindle and see that footstock spindle is clean and tightly seated. Regrind work center if worn. Work centers must fit taper of work center holes. Footstock must be checked for proper tension.